Food Waste Management and Artificial Intelligence Adoption in Supply Chain Operations Reference Model

Dr. Sonal Pandey

Middlesex College, North America International Education, USA, sonal.bhu@gmail.com

ABSTRACT: Unused food is discarded, lost, or uneaten; these are the three types of food waste. Despite their similarities, all three have critical differences within their definitions. Food waste or loss causes are numerous and occur at the production, processing, retailing, and consumption stages. Current estimates put global food loss and waste between one-third and one-half of all food produced. Loss and wastage occur at all food supply or value chain stages. In low-income countries, most loss occurs during production, while in developed countries, much food – about 100 kilograms (220 lbs.) per person per year – is wasted at the consumption stage. Everyday households around the world throw away tons of food while many people on the same planet are dying from hunger. Our reality is full of contradictory facts that we can ignore or not. For someone, this will be a good reason to get concerned and take care of their food waste, while others will need more reasons for that. A good reason would be the collection of data by local community to show the reality of the percentage of food waste in households. The U.S. Department of Agriculture estimates that more than 130 billion pounds (about 58966960000 kg) of food is wasted in this country alone every year – an average of more than 200 pounds of food per person. It is a staggering number, and combined with the approximately 17 percent of food going to waste in the rest of the world, it has real consequences for people everywhere (embrace relief.org). The cost of food for the preparation of meals is the second largest expense in households, right after personnel costs. This study aims to explore ways to reduce food wastes and losses and establish a better management of food disposal in households. Data was colected through a survey of local households in New Jersey. An in-depth survey was conducted with the help of Survey Monkey and 1000 local households were contacted in November 2022, with a brief introduction to the research topic. 891 respondents replied and showed interest in sharing their views on the topic and ready to share the data of their household food waste. To maintain confidentiality, I have anonymized the respondents as a number. The purpose of the descriptive data analysis was to show how important food waste management is and what the several reasons are for household food waste. With single-family settings, I also try to analyze the amount of food waste per family. The results of my analysis show the amount of food wasted in this area every month. Based on the analysis, there are suggestions about how we can minimize food waste. To give lots of suggestions, I implemented the SCOR (Supply Chain Operations Reference) model facilitated by Artificial Intelligence.

KEYWORDS: Artificial Intelligence, Data analysis, Food waste, Survey, SCOR model

Introduction

Food waste occurs in developed countries during the consumption phase, or you can say when the consumers are consuming the food. In developing countries however food waste occurs during the production and distribution phase. Due to its environmental, social, and economic impacts, food waste is attracting increasing attention in global food supply chains.

There are many phases at which nourishment can be wasted. Firstly, there is the agricultural stage at which food losses occur when, for example, a dry or very cold period or a plague will cause plants to die. This isa bigger problem in developing countries, by the reason that farmers often do not have the means to purchase fertilizer or pesticides or to water their crops and therefore will have greater losses at the agricultural (Ngoc, Kumar and Lin 2015).

Secondly, there is the harvesting stage at which the greatest losses happen if crops are in org delivered to Europe or the USA, because trading regulations and high demands cause wrong-sized or non-perfect-looking, but perfectly too be thrown away. This can be up to 50 percent of the whole harvest, but on average is 5-10 percent (cf. Thurn, 2011, 22 ff). Thirdly,

there is the post-harvest stage at which food is stored by farmers until it is picked up. At this phase much of it spoils, especially at very. Fourthly the logistics stage either brings a crop directly from the field to a distributor or takes it to processing first and delivers the end-product to a grocery. Losses at this stadium occur due to spilling and interruptions at the cold chain which especially cause meat and fish to decay. Fifthly, there is the processing phase at which waste occurs for many reasons such as wrongly calculated amounts or too long or wrong storage causing stocks to decay or as one-size cutting for example in fries' production at which many producers want equally shaped and sized fries and therefore do not use the outer parts of potatoes. Sixthly, there is the distribution stage at which food is squandered because of unhappiness about the quality or, if new commodities have arrived, the oldest ones are thrown away to make space for the new ones. In most cases this happens due to the best before date being expired or about to expire, even though the best before date is attached to no law which would forbid to sell nourishment after its expiration, but it just assures the food to keep certain characteristics. As opposed to this, the use-by date must not be expired because it assures products like meat to be harmless to health. Because bakeries often must keep their whole assortment available with the evenings being no exceptions, for example Austrian bakery.

Literally finally, the consumer stage causes a huge part of food waste, since end users are afraid of expired best before dates, just do not need certain ingredients for cooking any more or have leftovers from their meals which they throw away.

Consequences of food waste

Food waste could be used to alleviate the worldwide hunger problem. Second, food waste generates a huge amount of greenhouse gases, estimated to about 3.3 billion tons of CO_2 equivalent. food waste represents monetary losses, both for individuals and national economies. (Bravi, Francioni, Murmura, and Savelli 2020).

Methodology

In my research, I tried to find out main cause of food waste in household. I conducted in-depth survey with the help of survey monkey and contacted 1000 local households of new jersey in November2022 and provided a brief introduction to the research topic. After multiple reminders, 891 respondents replied and showed interest in sharing their views on the topic and ready to share the data of their household food waste. To maintain confidentiality, I have anonymized the respondents as a number. According to survey result 21% responded that there is no food wasted in their houses, 22% responded yes, there is food wasted in the family weekly basis and 57% households agrees that food wasted occasionally. In my research article I tried to cooperate SCOR model with Artificial inelegance to give better solution/suggestion for food waste management in households.

Community survey

Drawing on Surveys with community household about food waste, this research study construes the boundaries between food surplus and food waste, avoidable and unavoidable food waste, and between waste prevention and waste management. This study suggests that the first step towards a more sustainable resolution of the food waste issue is to adopt a sustainable consumption approach and tackle food surplus and waste throughout the food supply chain. The authors examine the factors that give rise to food waste in household and propose a framework to identify and prioritize the most appropriate options for prevention and management of food waste. It considers the three dimensions of sustainability (environmental, economic, and social), offering a more holistic approach in addressing food waste. Additionally, it considers the materiality and temporality of

food. The food waste hierarchy posits that prevention, through minimization of food surplus and avoidable food waste, is the most attractive option. The second most attractive option involves the distribution of food surplus to groups affected by food poverty, followed by the option of converting food waste to animal feed. Although the proposed food waste hierarchy requires a fundamental re-think of the current practices and systems in place, it has the potential to deliver substantial environmental, social, and economic benefits.

Factors that give rise to food waste in households according to survey

- Cooked more than required.
- Ordered more than required.
- Fresh eating habits.
- Guest.
- Eating habits of kids.
- I do not make shopping plans.

Table 1: Data collected by survey

Household Number	Average number of people in the family living together	About how often do you eat fat food (homemade or from outside	Response about the impotence of Recycling, waste management, and waste reduction	Does food get wasted in your family	How much quantity of food wasted weekly? In grams /lbs. (you can answer in decimals) Average of response.	Reason for food waste at home?
869	4	weekly	-Extremely - Important -Important -Somewhat important -Not sure	Mostly answered yes	Average 2.5lbs	Cooked more than required. Ordered more than required. Fresh eating habits. Guest. Eating habits of kids. I do not make shopping plans

Table 2: Data Analysis - For sample 869, N= 869

Category of Food	Mean	SD
Fruits and vegetables	2.06	0.966
Meat and meat products	1.58	0.780
Bread and bakery products	2.27	1.093
Milk and dairy products	1.82	0.883

*** significant at 0.1% level

Table 3: Descriptive statistics

Statistics	Result	Formula
Mean(average)	2.703932584	=Average
Median	1.321806479	=Median
Standard Deviation	3	=STDEV.S
Variance	1.747172369	=VAR.S
Skewness	0.266326492	=SKEW
Mode	3	=Mode

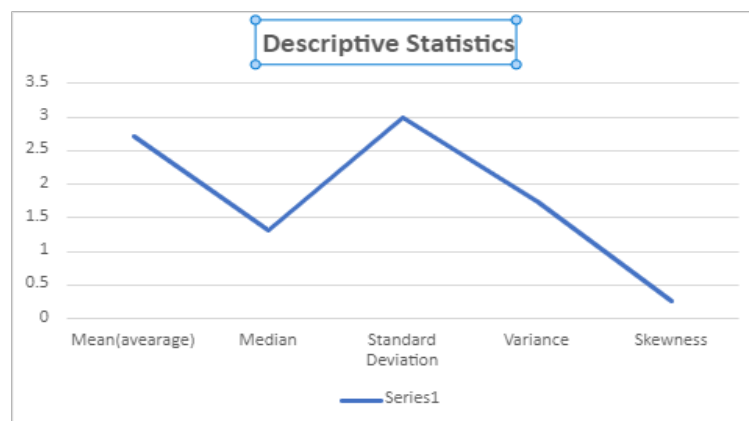
Figure 1: Descriptive Statistics

From the collected data set we have descriptive statistics for the data set
The average amount of food waste is 2.70 pounds. Since median is different from mean, this data set is not symmetrical, so waste distribution is not smooth and central. There is a mode of 3 and a skewness of 0.2663, which is slightly positive.

Table 4: Does food get wasted in your family – Survey response in percentage

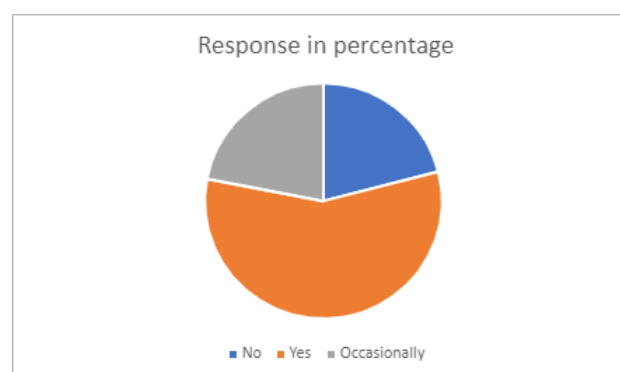| Does food get wasted in your family	Response in percentage
No	21%
Occasionally	22%
Yes	57%

Figure 2: Response in percentage

In 891 who replied survey and showed interest in sharing their views on the topic and ready to share the data of their household food waste. To maintain confidentiality, I have anonymized the respondents as a number. According to survey result 21% responded that there is no food wasted in their houses, 22% responded yes, there is food wasted in the family weekly basis and 57% households agrees that food wasted occasionally.

Table 5: Reasons of food waste – Survey response in percentage

Reason for food waste	Response in percentage
Because of eating habits of kids	12%
Because of Guest	3%
Cooked more than required	33%
Fresh eating habits	23%
Ordered more than required	3%
I do not make shopping plan	26%

Figure 3: Reasons of food waste

After asking about the reason, they replied to several distinct reasons food waste. I tried to keep the most common one and the other reasons I mentioned in the categories of other. Mostly agrees with the cooked more than required which is 33%, 23% percent answered fresh eating habits are the reason for food waste in their family so leftovers wasted. 12% percent answered because of kids eating tantrum food got wasted, 3% because of guest, they answered guest did not come so food got wasted and that give the reason of food waste as ordered more than required is also 3%.

According to collected responses through survey, data show the average food waste per family in the community is **about 3 lbs**. **weekly**, with the 4 count average family members living together.
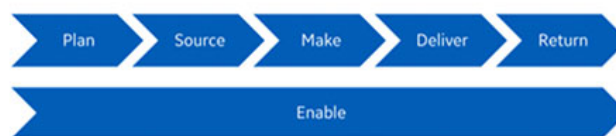

Figure 4: How to implement the food waste management to control food waste.
SCOR model

Plan - Planning is the first step and describes the activities used to develop the plans that run the supply chain. This includes gathering information about the available resources, determining requirements, and predicting customer demand. process that balances aggregate demand and supply to develop a course of action which meets sourcing, production, and delivery requirements.

Source - process that procure goods and services to meet planned or actual demand. Sourcing deals with procurement and obtaining materials from suppliers to meet market demand.

Make - process that transform products to finished state to meet planned or actual demand. The making process would be the production phase and is the transformation of raw materials into a finished product ready for the consumer.

Deliver - Processing that provides finished goods and services to meet planned or actual demand typically including order, transportation, and distribution management. The following process is the delivery step which is the transportation of the finished product to the customer.

Return - process associated with returning or receiving returned products for any reason.

Enable - process being associated with management of the supply chain. Including business rules, data, resources, facilities, contracts, supply chain network management, managing regulatory compliance and risk management.

Food Waste management process

From the food collection point, there would be a sorting point that sorts the food based on texture and transports it to a waste collection station. The waste collection station was responsible for disposing of waste in the most efficient way possible. Transport it to the fertilizer industry to be used to make organic fertilizers, transport it to the landfill site to be disposed of if it cannot be used, transport it to the incineration site to produce energy, or transport it to the gas production station to produce gas.
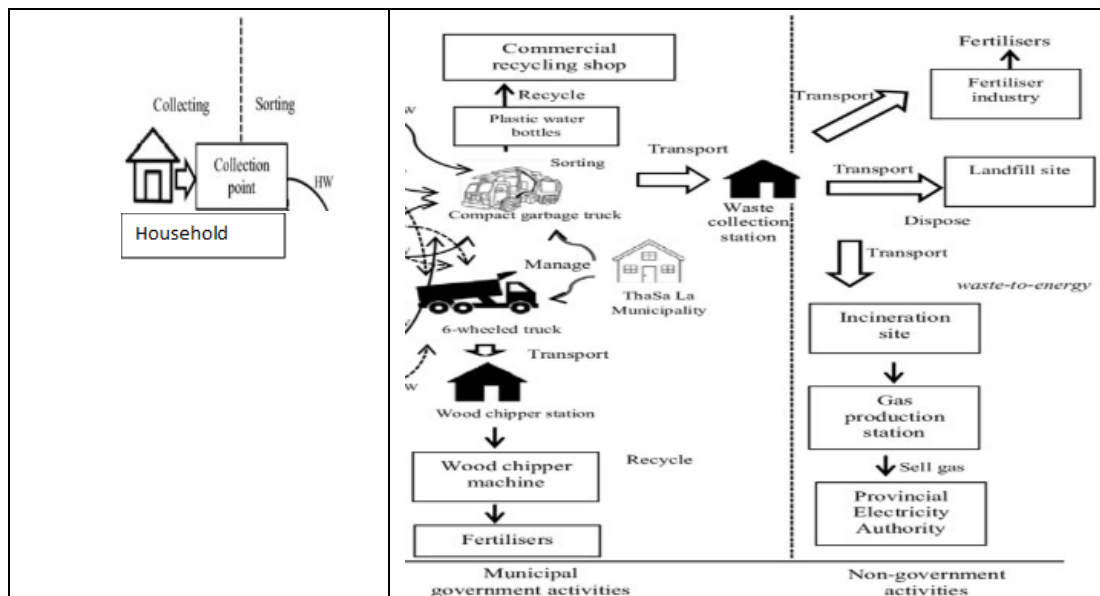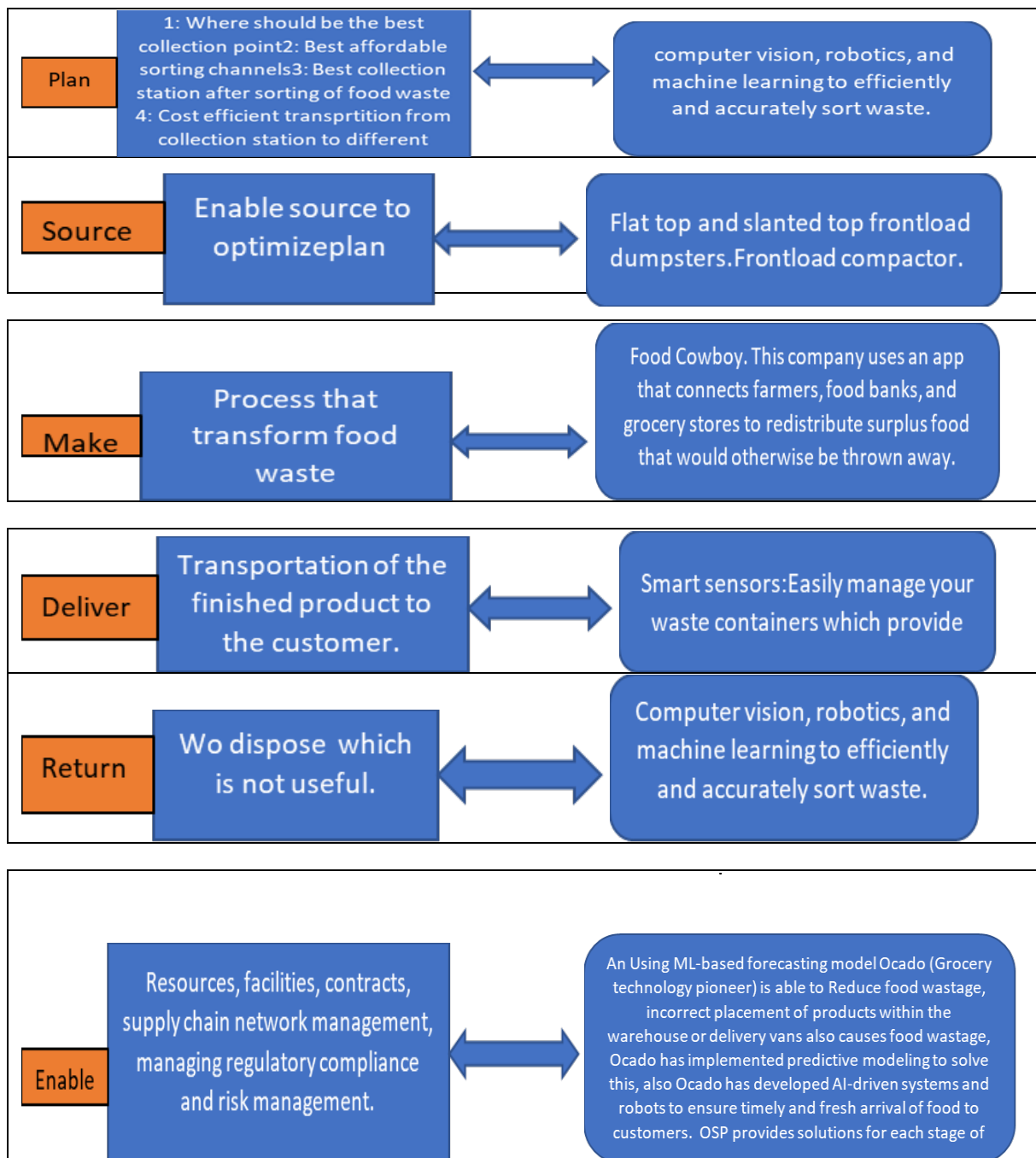

Figure 5: Food Waste management process

Table 6: Artificial Intellegence and SCOR Model Implementation in waste management process

Plan	1: Where should be the best collection point2: Best affordable sorting channels3: Best collection station after sorting of food waste 4: Cost efficient transprtition from collection station to different	⟷	computer vision, robotics, and machine learning to efficiently and accurately sort waste.
Source	Enable source to optimizeplan	⟷	Flat top and slanted top frontload dumpsters.Frontload compactor.
Make	Process that transform food waste	⟷	Food Cowboy. This company uses an app that connects farmers, food banks, and grocery stores to redistribute surplus food that would otherwise be thrown away.
Deliver	Transportation of the finished product to the customer.	⟷	Smart sensors:Easily manage your waste containers which provide
Return	Wo dispose which is not useful.	⟷	Computer vision, robotics, and machine learning to efficiently and accurately sort waste.
Enable	Resources, facilities, contracts, supply chain network management, managing regulatory compliance and risk management.	⟷	An Using ML-based forecasting model Ocado (Grocery technology pioneer) is able to Reduce food wastage, incorrect placement of products within the warehouse or delivery vans also causes food wastage, Ocado has implemented predictive modeling to solve this, also Ocado has developed AI-driven systems and robots to ensure timely and fresh arrival of food to customers. OSP provides solutions for each stage of

AI-based Approaches to Reduce Food Waste

Artificial Intelligence (AI) can play a significant role in reducing food waste. AI can be used to optimize supply chain management, predict demand, and reduce food spoilage.

One way AI can be used is by using Machine Learning (ML) algorithms to predict demand for food products. This can help to reduce food waste by ensuring that the right amount of food is cooked and served to the right people at the right time.

For example, a retail company can use historical sales data and weather forecast data to train an ML model to predict the demand for specific products. This can help the household

also to optimize its inventory management and reduce the amount of food waste (Simarenjeet 2023).

One example of a company using AI to reduce food waste is Food Cowboy. This company uses an app that connects farmers, food banks, and grocery stores to redistribute surplus food that would otherwise be thrown away. The app uses machine learning algorithms to match surplus food with the nearest food bank or shelter in need. As a result, Food Cowboy has been able to redistribute over 10 million pounds (about 4535920 kg) of food that would otherwise have gone to waste (Simarenjeet 2023).

Here is an example of python code that shows how to use a machine learning model to analyze kitchen data and provide insights on how to reduce food waste:

```
y_test. iloc[i]:
        print ("Menu item", X_test.iloc[i]['menu_items'], "is generating more waste than expected.
Consider adjusting portion size or ingredients.")" data-snippet-
id="ext.c7ba3d02d7c5191d1d7a71cea55925ec" data-snippet-saved="false" data-codota-
status="done"># Importing necessary libraries
import pandas as pd.
from sklearn. linear_model import LinearRegression
# Reading the data
data = pd.read_csv('kitchen_data.csv')
# Splitting the data into training and test sets
X = data [['menu_items', 'portion_size', 'ingredients']]
y = data['waste']
X_train, X_test, y_train, y_test = train_test_split (X, y, test_size=0.2, random_state=42)
# Creating and training the model
model = LinearRegression ()
model.fit (X_train, y_train)
# Evaluating the model
score = model. score (X_test, y_test)
print ("Model accuracy:", score)
# Using the trained model to make predictions
predictions = model.predict(X_test)
# Analyzing the data and providing insights on how to reduce waste
for i in range(len(predictions)):
    if predictions[i] > y_test. iloc[i]:
        print ("Menu item", X_test.iloc[i]['menu_items'], "is generating more waste than expected.
Consider adjusting portion size or ingredients.")
```

This code uses a linear regression model to analyze kitchen data and provide insights on how to reduce food waste. The model is trained using data that includes information about menu items, portion sizes, and ingredients. The model is then evaluated using the test data and its accuracy is printed out. Once the model is trained, it can be used to make predictions on new data and help identify which menu items are generating more waste than expected and suggest adjustments to reduce waste (Simarenjeet 2023).

Solutions

World food network implemented some solutions. WFN introduce AI to meet first two goals:
- First to minimize the amount of time food travels and help plans to grow more efficiently with less cost.
- Second to collect the requirement before process any food making.

Suggestions

Food waste can be reduced by developing technology that can be utilized in various parts of the food value chain and through education programs that focus on consumers' behaviour on healthy lifestyles and sustainable consumption.

Different techniques, such as education-based or structure-based, are used to encourage food waste prevention and management. Therefore, highlighting the current development in food waste management becomes important.

We can plan web application to have a login form and registration form. Dashboard design to fill different forms categories like - add food form and remove food form and for wastage entries we have food waste entry form, food waste entry form and food item waste entry form. Web application provides the user to generate analysed data in table and chart format. The extra food recipe can be collected by the nearest Orphanages who requested for the food and the food waste were given to the agricultural land for fertilization.

Conclusion

As a result, AI-based solutions can make a significant contribution to reducing food waste through optimal supply chain management, demand prediction, and spoilage reduction. We must, however, consider the ethical and societal implications, including the exacerbation of existing inequalities, job loss, and privacy concerns. The design and implementation of AI solutions must involve different stakeholders to ensure that they are ethical, fair, and socially responsible.

References

Bravi, L., Francioni, B., Murmura, F., & Savelli, E. 2020. "Factors affecting household food waste among young consumers and actions to prevent it. A comparison among UK, Spain, and Italy." *Resources, Conservation and Recycling*, 153: 104586. https://doi.org/10.1016/j.resconrec.2019.104586.
Simarenjeet, S. 2023, Januay 16. "Food waste management: AI Driven Food Waste Technologies." *Data Science Bloganthon.*
Ngoc, Bao Dung Thi, Gopalakrishnan Kumar and Chiu-Yue Lin. 2015. "An overview of food waste management in developing countries: Current status and future perspective." *Journal of Environmental Management* 157: 220-229. https://doi.org/10.1016/j.jenvman.2015.04.022.